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SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

I, Michael R. Oldenburg, a resident of Madelia, Minnesota, and a Citizen of the United States of America, have invented certain new and useful improvements in a

RETROFITTABLE SEVERE DUTY SEAL FOR A SHAFT

of which the following is a specification.

TITLE: RETROFITTABLE SEVERE DUTY SEAL FOR A SHAFT

PRIORITY

This application is a continuation of U.S. application serial number 10/173,250, filed June 17, 2002, which is a continuation of U.S. application serial number 09/690,524, filed October 17, 2000, now U.S. Patent 6,406,026, issued July 18, 2002, which is a continuation of U.S. application serial number 08/937,427, filed September 25, 1997, now U.S. Patent 6,186,507, issued February 13, 2001, all of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

The present disclosure is related to the field of seals for sealing rotary shafts, generally. The methods and apparatus are particularly related to the field of unitary combination lip and sleeve seals. More specifically, this is an improved seal adapted for use in severe duty applications including construction equipment, agricultural machinery, track driven vehicles, and other applications where oil or grease must be held in contact with rotary shaft and bearing assemblies. This seal and other seals of this type must also operate as excluder seals to keep lubricated surfaces free from corrosives, acids, other chemicals, dirt, mud, dust, abrasives, water and other contaminants. Even more particularly, this seal incorporates design features that enhance performance (compared to usual original equipment seals) when installed on shafts that have been slightly damaged by normal wear.

BACKGROUND AND SUMMARY

The present seal structure yields a very important benefit that has eluded other persons skilled in the art. It can be retrofitted to existing, worn machinery to enhance the protection of costly lubricated machine components. This seal can replace existing seals, and the performance

of this seal exceeds that of all other standard-sized, commercially available, conventional, lip and sleeve type seals. The only commercially available type of seal with performance comparable to this embodiment is the dual cone face seal. It is known by those in the art that dual cone face shields have disadvantages that significantly restrict their use. The seal disclosed here overcomes the two major inherent disadvantages of dual cone face seals — large size and high cost.

Conventional unitized lip and sleeve seals are much smaller than dual cone face seals. Since this seal can be installed as a direct replacement for ordinary seals, it can be specified and used without making any modifications to the design of a machine. The shaft, the bore, and the housing in which the seal operates are identical whether the present seal or conventional seals are used. Wherever dual cone face seals are desired, the machine must have been originally designed specifically for their use because they are much larger than ordinary seals. They are simply too big to fit all of the machine locations where their superior performance could justify the significant added cost.

The cost of making this seal is only a fraction of the cost of making a dual cone face seal. The additional cost can be substantial because the manufacturing cost for a dual cone face seal is currently between twenty and ninety times the cost of a conventional seal. A preferred embodiment of the present disclosure is expected to be two to three times the cost of a conventional seal.

The most important benefit of the seal now disclosed is that it can create permanently lubricated shaft and bearing assemblies that can withstand severe use. This seal may enable equipment manufacturers to improve the performance of their machinery by reducing maintenance requirements. It is believed that existing vehicles and other machines can be

retrofitted advantageously by replacing the original re-greasable seals with this new permanently lubricated seal.

It is an object of the invention to accomplish the foregoing and to teach the structure of a retrofittable severe duty seal for a shaft.

It is a further object of this disclosure to show an embodiment that may be used to seal rotary shafts used in track-driven vehicle tracks.

Another object is to provide an embodiment that may be useful in any application where a shaft and shaft bearing or bushing surfaces may be exposed to mud, dust, abrasives, cement, submersion, abrasive liquids or other substances that could damage relative rotary mechanical components.

Another object hereof to disclose a seal that lasts longer than previously known low cost seals that are adapted for use in severe duty applications.

Another object of the present disclosure is to make essentially all of the important benefits of a dual cone face seal available at a much lower cost.

Another object of the present disclosure is to make essentially all of the important benefits of a dual cone face seal available in a physically smaller assembly.

Another object of the present disclosure is to make essentially all of the important benefits of a dual cone face seal available in an assembly having the same physical dimensions as a conventional single lip or double lip seal.

Another object hereof is to provide an embodiment that can function as an excluder seal, as a grease seal, as an oil seal, and as a seal for other liquids at low and moderate pressures.

Another object of this disclosure is to provide a seal having a shaft-contacting sleeve that enables the seal to be installed on and to operate reliably with shafts having imperfections such as those ordinarily caused by wear and use.

Another object hereof is to provide a seal that is unitary in structure to thereby improve reliability, and to make installation of the seal easier than would be the installation of a seal that is comprised of two or more separable parts.

Another object is to provide a permanently lubricated seal for the track pins of a track-driven vehicle.

A further object is to provide a seal with sealing elements that include: a main sealing lip with a garter spring, three dust lips that contact the sleeve, one dust lip that contacts the inner surface of the housing, two face dust lips that contact the inner surface of the faceplate, and an elastomeric shaft-contacting faceplate ring.

These and further objects of the apparatus taught in accordance with this specification, the claims, and the appended drawing figures are set forth below.

DISCLOSURE OF THE INVENTION

The present disclosure shows a retrofittable radial lip seal for a circular rotatable shaft comprising a sleeve that may be disposed coaxially around the shaft. The sleeve has an inner end that would normally be in contact with the grease, oil, or other fluid to be contained within a housing, an outer end that would normally be exposed to ambient conditions, a bore that has an elastomeric coating, and a sleeve flange extending radially outward from the outer end of the sleeve and generally perpendicular to the sleeve axis. The sleeve flange is terminated with an outer edge. One or more circular elastomeric face lips extend coaxially from the sleeve flange outer face.

A circular elastomeric perimeter lip extends radially and outwardly from the outer edge of the sleeve flange to contact a generally cylindrical hollow seal case adapted for fitting into a bore, such as a bore that is formed through the wall of a housing, or other securement.

The case is formed from a generally cylindrical case body having an outside surface, or outside diameter, that may be disposed within a bore and in contact with the wall of the bore. An elastomeric coating may be affixed to the outside of the case body. By coating the outside of the metal case body with an elastomeric coating or layer, it is possible for the seal to securely fit a bore that may be worn or slightly damaged through use.

The inner surface of the case is smoothly finished in the region close to the outer end so that it is adapted for maintaining continuous operating contact with the perimeter lip of the sleeve flange. The case has an inner, fluid-contacting end, opposite the outer end. A case skirt extends radially outward from, and generally perpendicular to, the outside end of the case. Although it is believed preferable to form the case skirt from the case body, it may be possible to form the case skirt by attaching a separate piece. A case inner flange is located between the outer end and the fluid end of the case.

The case inner flange extends radially inwardly from, and generally perpendicular to, the longitudinal axis of the inside of the case. It is believed preferable to draw the case inner flange from the material of the case body. When formed in that manner, the material of the case body is doubled back on itself to yield two thicknesses of the case material for the distance between the case inner end and the case inner flange. The case reinforcement provided by the double layer of metal makes allows the use of a slightly thinner material to form the case body than would be necessary if the case material was a single thickness. However, other methods of construction may be adopted without departing from the scope of the invention disclosed. For instance, case

inner flange could be formed from a cup-shaped blank that is inserted into the case body and secured in place.

At least one sleeve-contacting, elastomeric, main sealing lip extends from the case inner flange to operatively contact the outer surface of the sleeve at a region near the inner end of the sleeve. The main sealing lip may be fitted with a garter spring to enable the assembly to operate at higher pressures. Testing has confirmed that the seal disclosed herein can operate reliably at a pressure of one atmosphere (15 p.s.i.) with shaft speeds of 700 feet per minute.

The maximum pressure at which this seal, like seals in general, can reliably operate decreases with increasing shaft speed. Testing may show that operation is satisfactory at pressures of approximately 100 p.s.i. or that slight changes could allow the seal to operate in the range of 100 p.s.i. Testing at higher these pressures and rotational velocities has not been concluded at the present time.

The main sealing lip and garter spring portion extends inwardly, toward the inner end of the sleeve, coaxially with the sleeve. At least one, and preferably two, dust lips are positioned to extend inwardly from the case into coaxial contact with the sleeve outer surface. One of the inwardly oriented dust lips, the mid-sleeve dust lip, may be disposed generally between the case inner flange aperture and the sleeve outer surface. The second sleeve contacting dust lip, the forward sleeve dust lip, is disposed generally midway between sleeve flange and the case inner flange. A third dust lip, the case flange dust lip, extends forwardly from the front surface of the case inner flange. The three dust lips and the main sealing lip are molded at high temperatures in one piece using a single mold operation and bonded to the case with suitable bonding agents. A resilient layer may cover the outside of the case to improve sealing in conditions where soft, damaged, or other less than optimal bore conditions exist that would impair reliable sealing with

a steel outer case surface. When the outer surface of the case is provided with such a rubberized covering, it is normally formed unitarily with the sleeve dust lips and the sealing lip. It is possible to cover the rearward surface of the case inner flange in the same operation with the same rubberized resilient compound. In applications that might expose the sealed materials to corrosion, it is preferred to cover with resilient rubberized material all of the portions of the seal case that are likely to contact the corrosive agents.

The case elastomeric coating is formed with a chamfer to minimize the likelihood that the seal will be damaged during installation. A case relief channel is also formed in the case elastomeric coating adjacent the case skirt. The relief channel relieves the tendency of the elastomeric coating to form a bulge at the edge of the bore that could cause the seal to become unseated and move axially after installation. It is also possible to provide radial ribs on the outer surface of the case elastomeric coating for the purpose of providing desired installation properties.

The seal is made into a unitary structure by inserting the sleeve inner end through the case inner flange so that the sleeve flange is inside the case near the case skirt. All of the voids between the lips, and the voids between the lips and the case, must be packed with grease before final assembly of the seal. The faceplate is then attached to the case skirt thereby retaining the sleeve within the case portion. It has been found that a high quality water-resistant grease is needed. One satisfactory grease is made by Esso Corporation and sold under the trade name "BEACON 325" although other products may also serve quite satisfactorily. The faceplate is attached to the case skirt and disposed in contact with the face lips that extend axially from the face of the sleeve flange and packed with grease. Although it is believed preferable to attach the faceplate to the case by crimping the peripheral edge of the faceplate around the outer edge of

the case skirt, the faceplate may also be attached to the skirt by welding, brazing, adhesive bonding, or by any other of the usual means of connecting such items. It is desired that the junction between the case skirt and the faceplate be impervious to external contaminants and internal lubricants at the temperatures, pressures, and other conditions in which the seal is operated.

A generally planar circular faceplate has an inside surface, an outside surface, and a central aperture slightly larger than the inside diameter of the sleeve. The plane of the inner faceplate surface is disposed generally parallel to the case skirt and the face of the sleeve flange. An elastomeric portion, or faceplate wiper ring, can be attached to the faceplate at the central aperture so that the faceplate wiper ring extends between the faceplate and the shaft. The faceplate wiper ring has an internal diameter that allows it to contact the shaft and thereby exclude contaminants from the remainder of the seal and the sealed components.

The sleeve bore is preferably coated with an elastomeric, or rubberized, coating to make it possible to obtain adequate sealing performance when the shaft condition is substandard due to wear, eccentricity, or other causes. A sleeve radial channel may be formed generally midway between the sleeve inner end and the sleeve outer end. The channel relieves shear tension that develops during installation. The result is that it is easier to install the sleeve and the potential for damage to the sleeve during installation is reduced.

Chamfers are provided at both the inner end and at the outer end of the sleeve bore to make installation less likely to damage the seal, the shaft, or the housing. In addition, the inner end of the sleeve outer surface is chamfered to make insertion of the sleeve through the housing easier and less likely to damage the dust lips or other components. The case inner end of the case outside surface is chamfered to make installation of the case within the housing easier.

The flange peripheral lip and face lips may be formed in the same molding operation that is used to mold the sleeve bore elastomeric coating. The design of the face lips may be designed with shapes similar to those of the peripheral lip and the three dust lips. However, an alternative design for the face lips is disclosed herein. The undercut face lips are adapted to provide superior performance in severe duty operating conditions. The advantage accrues because the undercut lip inside surface responds with increasing pressure in response to contact with materials that would penetrate the seal. The other lips contact the mating seal surface at distinctly different approach angles and with quite different elastomer shapes and configurations.

An alternative form of main sealing lip is favored for some very dirty applications, such as in agricultural machinery. In the alternate embodiment, the main sealing lip and garter spring are replaced by a triple radial wiper set, or triple flat lip. In addition, the two sleeve contacting dust lips may also be eliminated in this alternative embodiment. The triple flat lip design may be less susceptible to catastrophic damage by the infiltration of small amounts of foreign materials than are the usual main seal lip and garter spring sets. It is also possible to produce the design with more or fewer lips; for example, a quadruple lip design may be desired in some applications.

It is preferred to have the inner, or skirt-contacting, side of the faceplate smoothly finished to reduce wear on the face lips of the seal. Likewise, the outer surface of the sleeve, the sleeve flange inner face, and the perimeter lip-contacting case inner surface may be finished to a condition of low surface roughness to reduce the amount of wear to which the various elastomeric seal lips are subjected. For this reason, it is generally preferred to make the sleeve, case, and faceplate of metal such as stainless steel, carbon steel, or similar materials. It is to be

understood, however that the sleeve, case, and faceplate may be made from other metals and also from non-metallic materials.

In seals of this nature, the seals are normally described by reference to the cross-sectional configuration. The seal of the present embodiment may readily be manufactured in sizes between 0.5 inches and 26 inches with other sizes available on request. By way of example only and without any limitation on the configuration of embodiments of this disclosure, a representative seal may have an inside (shaft) diameter of $3\frac{1}{8}$ ", an outside (bore) diameter of $4\frac{1}{8}$ ", and a faceplate diameter of $4\frac{3}{8}$ " with an overall width of about $\frac{1}{2}$ ". The various dimensions do not scale proportionately. For example, the same type of seal may be manufactured for a $6\frac{1}{4}$ " shaft diameter but still have an overall width of $\frac{1}{2}$ " and be designed to fit into a $7\frac{3}{4}$ " bore. Seals adapted to various purposes may vary in width from less than $\frac{1}{8}$ " to over 1" but generally have a width between $\frac{1}{4}$ " and $\frac{3}{4}$ ".

It is to be understood, as well, that many different formulations of the elastomeric, or rubberized, elements may function satisfactorily. Viton®, nitrite, carboxylated nitrile, polyacrylate, ACM, fluoroelastomers, and silicone compounds are known to provide useful operational characteristics when adapted for incorporation within the seal presently disclosed. Other materials may also be incorporated to confer chemical resistance, extreme temperature resistance, expanded operating pressure range, wear resistance, or other desired properties to the final seal assembly.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 shows a cross-sectional profile of the structure of an embodiment according to the present disclosure.

Fig. 2 shows a cross-sectional profile of the structure of an alternative embodiment of the embodiment of Fig. 1 having an alternative configuration for the main sealing lip.

Fig. 3 shows an alternative configuration of the seal of Fig. 1 with an alternative shape for the face lips.

Fig. 4 shows a representative assembly of a type that is adapted for receiving the retrofittable seal of Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the various figures of the accompanying drawing, Fig. 1 depicts a cross-sectional profile of an embodiment of the retrofittable severe duty seal **20** fitted onto a shaft **21**. A cylindrical sleeve **22** is disposed coaxially over the shaft. The sleeve inner end **24** extends into the sealed region, normally a housing or containment for oil or grease for lubricating gears or bearings. To simplify nomenclature in this specification, the side or end or surface of a component that is oriented toward the lubricants, lubricated components, or other media from which it is desired to exclude dust, water, mud, and other environmental contaminants may be referred to using the terms “inner,” “inward,” “inside,” and similar terms. The words “outer,” “outward,” “outside” and similar terms may be used to refer to the side, or end or surface of a component that is oriented away from the sealed region, toward the exterior of a housing, or toward the unsealed overall environment into which a shaft extends.

Between the sleeve inner end **24** and the sleeve outer end **26**, the sleeve bore **28** may be coated with an elastomeric coating **30**. The optional sleeve bore elastomeric coating **30** is desirable because it may prevent leakage from between the seal **20** and the shaft **21** even when the shaft is worn or damaged. The sleeve flange **32** extends radially outwardly from the sleeve

outer end **26**. The sleeve flange **32** has a sleeve flange outer edge **34** at its outer periphery. At least one, and preferably two, face lips **36** extend coaxially outwardly from the sleeve flange outer face **38** and a perimeter lip **40** extends radially outwardly from the sleeve flange outer edge **34**. The sleeve bore elastomeric coating **30**, the face lips **36**, and the perimeter lip **40** may be integrally formed and bonded to the sleeve **22** in a single injection molding operation.

A seal case **50** is disposed coaxially outside the sleeve **22**. The seal case **50** has a generally cylindrical case body **52** designed so that the case outside surface **54** can fit into and seal against a bore in a housing or flange through which the shaft **21** to be sealed extends. It is preferred to enclose the case outside surface **54** with an optional case elastomeric coating **56**. The seal **20** is less likely to leak when installed in a damaged bore if the optional case elastomeric coating **56** is provided. The case body **52** has a smoothly finished perimeter lip-contacting case inner surface **58** in the region near the case outer end **60**.

The case inner end **62** is axially opposite the case outer end **60** and the case skirt **64** that extends radially outwardly from the case outer end **60**.

A case inner flange **66** extends radially inwardly from the case body **52** toward the sleeve **22**. The case inner flange **66** has a circular central aperture through which the shaft **21** and sleeve **22** fit. When the case inner flange **66** is drawn or otherwise made from the case body **52** it is possible to simultaneously form a case reinforcement **68** with a double layer of the material from which the case body **52** is made.

The main sealing lip **70** attaches to the case inner flange **66** and extends both axially inwardly and radially inward from the case inner flange **66**. The main sealing lip **70** contacts the sleeve outer surface **72** to form the primary sealing element by which the contents (generally fluids) of the sealed volume are prevented from transferring to the outside of the assembly. The

main sealing lip **70** is optionally biased against the sleeve outer surface **72** by a garter spring **74**. The sleeve outer surface **72** may be polished or otherwise finished to reduce wear of the main sealing lip **70**.

Additional sealing elements are situated axially outwardly from the main sealing lip **70**. These additional dust lips may extend between the case body **52**, particularly the case inner flange **66**, and the sleeve outer surface **72**. A mid-sleeve dust lip **75** may be located generally between the case inner flange **66** and the sleeve outer surface **72**. A forward sleeve dust lip **76** may be disposed against the sleeve outer surface **72** at a location close to the sleeve flange **32**. A case flange dust lip **77** may extend from the case inner flange **66** to contact the sleeve flange **32**. The case elastomeric coating **56**, the main sealing lip **70**, the mid-sleeve dust lip **75**, the forward sleeve dust lip **76** and the case flange dust lip **77** may be integrally formed and bonded to the case body **52** and case inner flange **66** in a single injection molding operation.

On the inner end of the case body **52**, the case elastomeric coating **56** is finished with a case elastomeric coating chamfer **78** to make it easier to install the seal **20** without distortion or damage. A case outside diameter relief channel **79** is formed in the case elastomeric coating **56** adjacent the case skirt **64**. The relief channel **79** relieves axial shear stresses from the case elastomeric coating **56** that may be induced by the process of installing the seal **20** into a bore.

Three main sub-assemblies, the sleeve **22**, the case **50**, and the faceplate **81** are interconnected to form a complete seal **20**. These three sub-assemblies are normally made primarily of steel or another metal that is shaped, worked, and polished using conventional metalworking techniques and commercially available equipment. It may be advantageous to smooth the metal surfaces that are contacted by the various elastomeric components to obtain a metal finish having low surface roughness. Carefully shaped and molded elastomeric

compounds are bonded to the metal components in the configurations shown in the accompanying drawing. It is possible to form the elastomeric components and attach them to the metal structures in a variety of ways; however, injection molding is believed preferable for these purposes.

Final assembly of the seal **20** is performed by carrying out four additional steps. First, water-resistant grease **80**, such as Esso Beacon 325™ is packed to fill all of the voids between the lips and between the case inner flange **66** and the case skirt **64**. Second, the sleeve **22** is inserted into the seal case **50** so that the case flange dust lip **77** contacts the sleeve flange **32** and the perimeter lip **40** contacts the perimeter lip-contacting case inner surface **58**. Third, grease **80** is packed into the interstices between the individual face lips **36** and also between the perimeter lip **40** and the outermost of the face lips **36**. Fourth, the faceplate **81** is affixed to the case skirt **64** by crimping or other means to complete the assembly and unitizing process.

After the faceplate **81** is attached to the case skirt **64**, the faceplate inner side **82** contacts the face lips **36** and the sleeve flange inner face **84** is brought into contact with the case flange dust lip **77**.

An optional elastomeric faceplate wiper ring **86** can be bonded to a central aperture in the faceplate **81** coaxial with, and through which, the shaft **21** extends. The periphery of the faceplate **81** may be finished with a peripheral faceplate crimp edge **88** for crimping over the case skirt **64** when the faceplate **81** is attached by crimping.

A sleeve radial channel **90** is preferably formed within the sleeve bore elastomeric coating **30** to relieve shear as the sleeve **20** is fitted to a shaft. The sleeve **22** is finished with a sleeve outer end chamfer **92** and a sleeve inner end chamfer **94** to reduce the potential for tearing of the sleeve bore elastomeric coating **30** and for distortion of the sleeve **22** during installation of

the seal **20**. Likewise, the seal case **50** may be fitted with a case inner end chamfer **96** to reduce damage to the case elastomeric coating **56** when the case is fitted with elastomeric coating and to prevent case distortion in embodiments without case elastomeric coating **56**.

It is believed preferable for the face lips **36** to be sharply angled radially inwardly with an acute point at the innermost portion of each of the face lips **36**. In order to form a lip having such a shape, it may be necessary to include a face lip undercut angle **98** that is less than **90** degrees to obtain the desired performance characteristics. The face lips **36** may be formed having a generally cross-section.

Fig. 2 shows an embodiment wherein the single main sealing lip **70** shown in Fig. 1 is replaced with a triple lip main seal **100**. It may be desirable to also eliminate the mid-sleeve dust lip **75** and the forward sleeve dust lip **76** from embodiments having the main sealing lip **70** replaced by the triple lip main seal **100**.

Fig. 3 shows an embodiment of the seal **20** wherein the spacing relationship between the dust lips **75 76 77** is modified slightly from the relationship depicted in Fig. 1.

Fig. 4 shows a representative application in which the seal **20** may be installed, specifically, a worm gear drive assembly **101**. The seal **20** is fitted into the bore of a housing **102** to seal a bearing **104** from outside contaminants and to prevent lubricants from leaking out of the housing **102** around the output shaft **106** of the worm gear drive assembly **101**.

INDUSTRIAL APPLICABILITY

From the foregoing, it may be readily understood by those skilled in the art that the embodiments disclosed are applicable to industry and mechanical power transmission generally, and to machinery and vehicles that are operated in severe environments, particularly. Incorporation of the present embodiment into new and existing equipment is expected to

substantially reduce the maintenance requirements of many types of construction and agricultural equipment.

Changes and modifications in the specifically described embodiments can be carried out without departing from the scope of the invention which is intended to be limited only by the scope of the appended claims.

REFERENCES TO DRAWING NUMBERS

| | | | |
|----|---|-----|--------------------------------------|
| 20 | Retrofittable Severe Duty Seal for a Shaft | 72 | sleeve outer surface |
| 21 | shaft (reduced scale) | 74 | garter spring |
| 22 | sleeve | 75 | mid-sleeve dust lip |
| 24 | sleeve inner end | 76 | forward sleeve dust lip |
| 26 | sleeve outer end | 77 | case flange dust lip |
| 28 | sleeve bore | 78 | case elastomeric coating chamfer |
| 30 | sleeve bore elastomeric coating | 79 | case outside diameter relief channel |
| 32 | sleeve flange | 80 | grease |
| 34 | sleeve flange outer end | 81 | faceplate |
| 36 | face lips | 82 | faceplate inner side |
| 38 | sleeve flange outer face | 84 | sleeve flange inner face |
| 40 | perimeter lip | 86 | elastomeric faceplate wiper ring |
| 50 | seal case | 88 | peripheral faceplate crimp edge |
| 52 | case body | 90 | sleeve radial channel |
| 54 | case outside surface | 92 | sleeve outer end chamfer |
| 56 | case elastomeric coating | 94 | sleeve inner end chamfer |
| 58 | perimeter lip-contacting case inner surface | 96 | case inner end chamfer |
| 60 | case outer end | 98 | face lip undercut angle |
| 62 | case inner end | 100 | triple lip main seal |
| 64 | case skirt | 101 | worm gear drive assembly |
| 66 | case inner flange | 102 | housing |
| 68 | case reinforcement | 104 | bearing |
| 70 | main sealing lip | 106 | worm gear drive output shaft |